

# **SOME PRELIMINARY STUDIES ON RESIDUAL OF DIOXIN (2,3,7,8-TCDD) USED IN VIETNAM WAR AT VIETNAM-LAOS BORDER (KONTUM-QUANGNAM PROVINCES AND LONGTERM EFFECTS OF DIOXIN INTO NATURAL ECOSYSTEMS AND BIODIVERSITY IN THIS AREA**

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## **Abstract**

Up to now, more than 40 years ago after the end of the sprayed operation, soil in the Vietnam-Laos border (Kontum-Quangnam provinces), particularly in the Charly range and adjaction area are polluted by dioxin. Analytic results of dioxin residual in samples of soil, stream sediment collected in late June and early July 2008 show that concentrations of 2,3,7,8 TCDD ranged from 106.57 to 845.48 ppt (ng/kg drying soil). These concentrations of 2,3,7,8-TCDD are lower than the permissible level for non-agricultural soil of the US Environmental Protection Agency (USEPA) being 1,000 ppt, but higher than the permissible level for agricultural soil (27 ppt). Concentrations of 2,3,7,8-TCDD in soil are higher than stream sediment.

In 2008, preliminary research results show that hebicides used in the war have caused long term impacts into natural ecosystems and biodiversity of this area. The natural vegetation in Charly range before spraying is primary forest, with abundant and storied forest but can not rehabilitated, and now only grasses, bushes occurred. A such degraded forest vegetation, species composition and quantity of small size mammal belonging to Chidoptera and Rodentia orders in the Charly range are lower than unsprayed other area with the same landscape (Chu Mom Ray range). Biodiverse index (Shannon index-H') of various animal groups in this area is also lower than unsprayed area: Average value H' of fishes of streams in the Charly valley 0.9340, lower than H' value of fishes in streams of unsprayed areas (1. 1561-1. 2738); H' value of insects in the Charly range fluctuated 1.7544-4.3803, lower than unsprayed areas (2.8791-4.6697).

## **Introduction**

Approximately 80 million litres of herbicides containing at least 366 kg of dioxin were sprayed over 10-15% of the area of Southern Vietnam during the time from approximately 1962 to 1971. Among sprayed area of Southern Vietnam, the mountainous forest along Vietnam-Laos border at Kontum and Quangnam provinces was heavily sprayed, especially, the Charly range located in Kontum (former an entrenched fortification of US army in the war) there was both sprayed and haevily destroyed by bomb. According to various materials during the Ranch Hand operation, this area was aerielly sprayed by 910,000 gallon of Agent Orange, 74,700 gallons of Agent Blue, and 131,340 gallons of Agent White.

Until now, some investigations on residual of dioxin and longterm effects of them into biodiversity that were implemented in Aluoi (Thuathien-Hue), Mada, Trian reservoir (Dongnai) ect. (4,8,9,11,13,15,16,17,18) but there are not studies carried out in area of Vietnam-Laos border belonging to Kontum-Quangnam provinces. Recent time 38 CS containers untouched or broken were found in these areas. Of them 7 CS containers with weight of 100-200 Kg found in Ro Koi commune (Sathay-Kontum). Chemical army and the military of Kontum province have conllected and treated these toxic containers. Therefore, in the cope of the programe 33, a project "Investigation, assessment of longterm effects of herbicide used in the war by US armed forces into biodiversity in some areas along Vietnam-Laos border at Kontum, Quangnam provinces" is implemented with objectives: to have data on residual of dioxin and evaluation longterm impacts of them into biodiversity in natural ecosystems of these areas. This paper presents some preliminary research results through 2 surveys in 2008.

## Materials and Methods

1. Based on data on spraying herbicide in the war, 3 areas were distinguished: strongly sprayed areas being the Charly range belonging to Sathay district. Moderately sprayed areas being Cha Val (Namgiang district, Quangnam province), and seldom sprayed or unsprayed areas but the same in natural features with above areas and used as a blank area being Chu Mom Ray range. Residual dioxin and status of biodiversity are investigated in these areas.

2. Collecting soil and sediment samples at 15 locations for analysis of dioxin (2,3,7,8-TCDD). Soil samples are collected in the depth of 20-30cm. Sediment samples are mainly collected in littoral of streams and rivers, there deposited mud or mud-sand, water depths of approximately 10 to 30cm. All samples are place in pre-cleaned PVC bag and frozen. Method 8290 EPA (US America) is used for analysis of residual dioxin in soil, sediment. The high-resolution gas chromatography and high-resolution mass spectrometry (HRGC/HRMS) is use for analysis of dioxin. Residual Dioxin concentration (2,3,7,8-TCDD) is calculated by formula:  $C = (c_m \times 100)/M$ . Of them, C: 2,3,7,8-TCDD concentration (ppt-ng/kg);  $c_m$ : 2,3,7,8-TCDD mass in 1  $\mu$ l diluted sample (pg/ $\mu$ l); M: dry mass of sample (g). Institute of Chemistry belonging to Vietnamese Academy of Science and Technology has responsibility to collect, preserve samples of soil, sediment and analyze residual dioxin.

3. Investigation of biodiversity is implemeted by standard methods for study fauna and flora: Representative inventory lines and stations for investigation are choose in the map, sample plots are established for evaluating biomass (plant), quantitty of wild animals. Collection of bats, rodents, hydro-organisms by special traps, and nets. Light traps is used for collecting insects. Objectives for studies including plants and forest vegetation; mammals; birds; reptiles and amphibians; soil invertebrates; insects; aquatic organisms (plankton, benthos and fishes). Calculating biodiversity index (Shannon-Weiner-H' và Margalef-D) of each other groups. Abundant indice of bad is calculated by formula of Curtis and McIntosh, 1950.

Besides, we also use analysis and interpretation of satellite images, primary Landsat, of the study areas, combined with US government information on where herbicide spray missions were during war time.

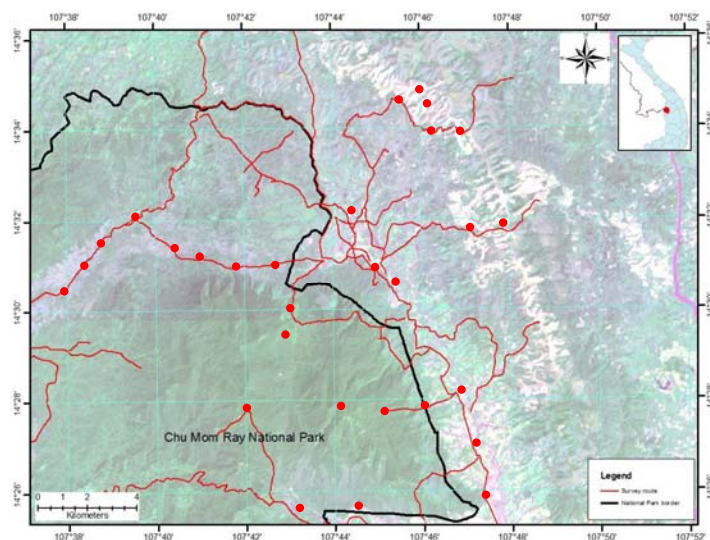


Figure 1. Survey lines (red line) and stations (red circle) at Kontum, 2008

## Results and Discussion

### 1. Residual dioxin in soil and sediment

Analysis show that all of soil and sediment samples collected from investigational areas that have residual of dioxin (2,3,7,8-TCDD) with various level, ranged from 106.57 to 845.48 ppt (ng/kg drying soil) (see table 1).

These TCDD levels are lower than the permissible level for non-agricultural soil of the US Environmental Protection Agency (USEPA) being 1,000 ppt, but higher than the permissible level for agricultural soil (27 ppt). Generally, concentrations of TCDD of investigational areas are higher than TCDD levels of aerially sprayed zones in previous investigations of various authors at Aluoi, Mada, Dongnai (3, 15).

Table 1. Residual dioxin (2,3,7,8-TCDD) in soil, sediment from investigational areas at Vietnam-Laos border at Kontum, Quangnam provinces, 2008

Samples	Locations	Mass of drying sample (g)	Concentrations (ppt = ng/kg)	R%
Charly range				
SL01	Soil	20.3625	845.48	43.0
SL02	Stream sediment	20.5698	386.53	43.2
SL05	Stream sediment	20.2198	619.19	45.0
SL06	Stream sediment	20.8354	284.17	48.4
SL09	Stream sediment	20.6539	494.87	52.2
SL12	Soil	20.5329	332.73	52.2
SL13	Soil	20.4272	481.80	52.8
SL18	Stream sediment	20.8565	135.40	46.6
Chu Mom Ray range				
CMR01	Stream sediment	20.4451	309.36	50.8
CMR02	Soil	20.3529	345.11	54.6
Nam Giang, Quangnam				
QN01	River sediment	20.6238	106.57	54.6
QN02	River sediment	20.4598	152.73	50.2
QN03	River sediment	20.5164	429.50	47.2
QN07	River sediment	20.1524	343.98	54.4
QN08	River sediment	20.2985	376.48	40.2
<b>BLK02</b>	<b>Blank sample</b>	<b>20.3521 (Na<sub>2</sub>SO<sub>4</sub>)</b>	<b>0</b>	<b>51.2</b>

TCDD levels in Ro Koi commune, located in the valley of Charly range (up stream of Dak Su), fluctuated from 332.73 to 845.48 ppt are higher compared to locations in down stream of Dak Su at Sa Nhon commune (135.40 ppt). Residual TCDD in Chu Mom Ray ranged from 309.36-345.11 ppt but lower than TCDD levels in Ro Koi commune. TCDD concentrations in soil are higher than in sediment.

## 2. Status of biodiversity

### 2.1. Forest vegetation

There are types of forest vegetation in Charly range as following:

- Poor forest only distributed in valley and along brooklet on mountain-side of Charly range. Forest structure is simple including woody plants (height 15-20m), diameter 20-25cm, density of about 300 plants/ha; secondary forest with density of 600-700 plants/ha, the height of plant is lower.
- Bushy vegetations distributed as pieces intermix grasses covered almost area from valley to mountain-top.
- Grassland with eudominant grasses like *Imperata cylindrica*, *Saccharum spontaneum*, *Erianthus arundinaceus*, *Miscanthus floridus*. Of them, along grass (*Imperata cylindrica*) is dominant species with the most area.
- Agriculture vegetation including caoutchouc, pine, manioc, rice. Among them, rubber trees develop in down hill, but pine develop in mountain-side.

Meanwhile, Chu Mom Ray is used as blank area that has types of vegetation following:

- Evergreen close forest with quadruple-canopy structure including woody plant, the height of 25-30m, diameter of 40-45cm; Layer of under closed canopy with the height of 10-15m; bushy plants of 2-3m and; grass
- Close semideciduous forest.
- Bushy vegetations recovered after kainging and forest fires, distributed along roads.
- Grasslands recovered after kainging and forest fiers with eudominant grasses like *Imperata cylindrica*, *Saccharum spontaneum*, *Erianthus arundinaceus*, *Miscanthus floridus*

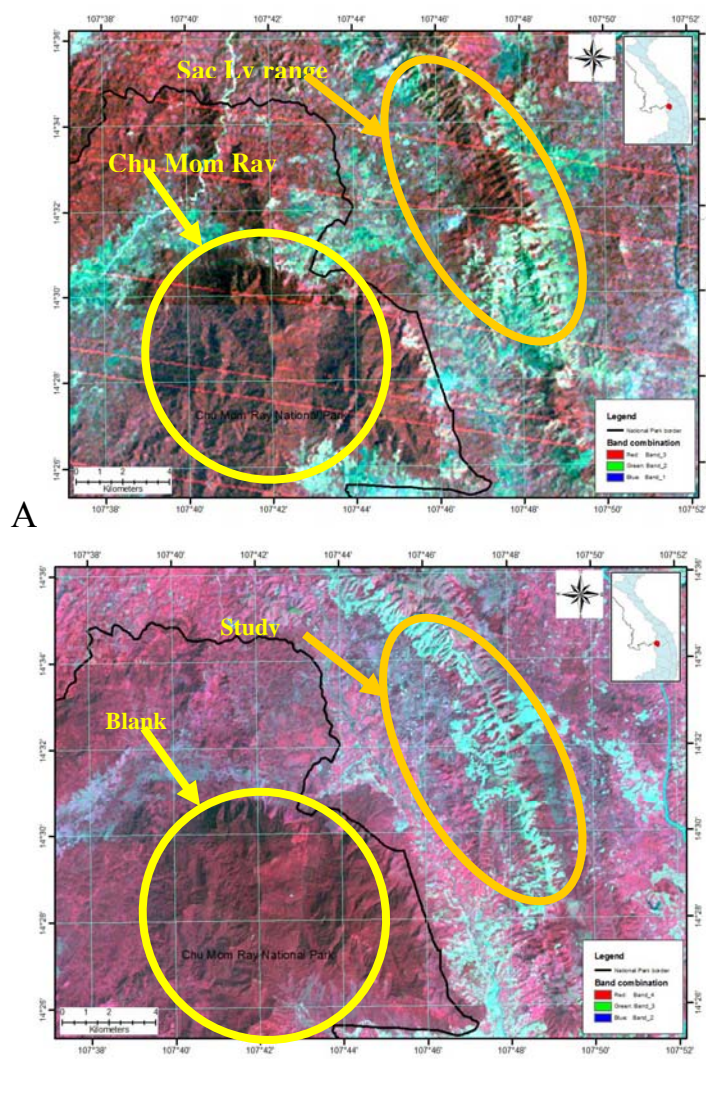


Figure 2. Satellite images of study areas in Kontum. A: Landsat MSS, 134-50; date 24, Feb. 1975  
B: Landsat ETM, 124-50; date 17, Oct.2001

**Remarks:** by data, before spraying of herbicides, both Charly range and Chu Mom Ray are tropical wet multy layer forests with climax vegetations including high hard-woody trees belonging to genera such as *Azelia*, *Dalbergia*, *Lagestroemia*, *Hopea*, *Aphanamixis*, *Vatica*, *Lithocarpus*, *Castanopsis* ect. Up to now, in Charly

range, strongly degenerative vegetations occurring with bush, grassland and poor forest and less abundant species composition of plant, that indicated for degradation of living environment. Meanwhile, in Chu Mom Ray, Evergreen close forest and close semideciduous forest are still occurring to nowadays. It can explain that the Charly range (former an entrenched fortification of US army in the war) there was both sprayed and heavily destroyed by bombing many times. Tropical close forests were immediately destroyed (see fig.2A). After a long term when the original forest cover disappeared from defoliation, the surface soil was eroded by rains. Favorable soil humidity, light, and temperature conditions for the growth of forest trees were lost. There are not seedlings and seeds of forest trees to regenerate here. Invasion of bush, along grass and others develop, and grass fires were sparked during the dry season. These invasions of bush and grass have prevented ecological succession and normal tropical forest regeneration (see fig. 2B).

### 2.2. Small mammals (bats and rodents)

The total 372 hours for trapping of animals implemented in the field, including 144 hours to collect bats by harpnet, and 360 traps for collecting rodents. The total 18 species of small mammals belonging to 6 families are recorded (12 species of bat and 6 species of rodent). There are only 4 species in Charly range, of them 3 species of rodent), 5 species in Cha Val. Meanwhile 11 species of small mammals are recorded in Chu Mom Ray range. The frequency of occurrence in Charly range is calculated 0.006, in Cha Val of 0.1, these values are lower than one in Dak Tao station in Chu Mom Ray, frequency of 0.3.

### 2.3. Terrestrial invertebrates

Research results on insect show that there are not extraordinary changes on morphology of insectine species in study areas. Biodiversity index ( $H'$  and  $d$ ) of insect in both forest and grassland at Charly range are lower than in Chu Mom Ray (table 2).

Table 2. Biodiversity index of insect through average values of  $H'$  and  $d$  in study areas

<b>Biotops</b>	<b>Locations</b>	<b><math>H'</math></b>	<b><math>d</math></b>
Forest	Charly range	4.3803	19.3689
	Cha Val	4.7389	27.0695
	Chu Mom Rây range	4.6697	25.0433
Bush, grassland	Charly range	3.9559	15.1714
	Cha Val	4.2144	17.0983
	Chu Mom Rây range	4.1587	16.9752

In Charly range, species composition of nematods freely living in soil is moderately poor. 36 species belonging to 14 families are recorded. Meanwhile, in Chu Mom Ray, fauna of nematods are more abundant, recorded 42 species belonging to 17 families.

### 2.4. Aquatic communities

Research results on aquatic communities including phytoplankton, zooplankton, macrobenthos and fish in study areas do not found extraordinary change on morphology of all groups. There is not the difference in species composition and biodiversity index of plankton and benthic animals of all waterbody types (streams, rivers) in Charly range and Chu Mom Ray range. However, species composition of fish of Dak Su river, flowing along south-western mountain-side of Charly 24 species are less abundant compared to fish fauna of Sa Thay river, 42 species of fish. Average value  $H'$  of fish in Dak Su reached only 0.9340 being lower than others,  $H'$  ranged 1.1561-1.2738.

### Conclusion

1. Up to now, residual TCDD are found in soil and sediment of Vietnam-Laos border area at Sathay (Kontum province) and Namgiang (Quangnam province), ranged from 106.57 to 845.48 ppt (ng/kg drying soil). These concentrations of 2,3,7,8-TCDD are lower than the permissible level for non-agricultural soil of the US Environmental Protection Agency (USEPA) being 1,000 ppt, but higher than the permissible level for

agricultural soil (27 ppt). These concentrations of TCDD here are generally higher than TCDD levels of aerially sprayed zones in previous investigations of various authors at Aluoi, Mada, Dongnai.

2. Preliminary research results on status of biodiversity in Vietnam-Laos border areas at Kontum and Quangnam province, show that toxic chemicals sprayed in the war still impact on environment and leave behind long-term consequences to ecosystems and biodiversity. In heavily sprayed areas, erosion of soil occurring, natural vegetations mainly are bush, along grass, exhausted forest, flora is poor in species composition, those that indicate degradation of tropical forest ecosystems and habitats. It has not source of seedlings and seeds of forest trees. These have prevented ecological succession and normal tropical forest regeneration. Biodiversity index of some biotic groups such as small mammals, insects, fishes in heavily sprayed areas are lower than moderately sprayed or unsprayed areas.

## REFERENCES

1. Arthur W. Galston, 1883. Herbicides; their action mode. *Proceeding on International conference on Herbicides used in the war and longterm effects into nature and human*". Hanoi, 1983: 9-1.
2. Arthur H. Westing, 1984. Herbicides in war The Long-term Ecological and Human Consequences. *SPIRI, Taylor & Francis Ltd., 208 pp.*
3. Dwernychuk L.W, Hoang Dinh Cau et al., 2002. *Chemosphere 47: 117-137.*
4. Dang Huy Huynh et al., 2000. Full report of the project Investigation, study of impacts of toxic chemicals into biodiversity in Aluoi and adjaction areas. *Unpublished Document of IEFR and Program 33.*
5. Dang Huy Huynh, Ho Thanh Hai, 2005. *ETFRN News 43-45: 90-92.*
6. ERDAS, 1999. Imaging version 8.4.
7. ESRI 1999-2006. Inc. ARC Map 9.2.
8. Hatfield Consultants Ltd. Canada, 1996. Preliminary assessment of Environmental Impacts related to Spraying of Agent Orange Herbicide During the Vietnam War. *Final Report, 67 pp.*
9. Hatfield Consultants Ltd. Canada, 10-80 Committee Vietnam, 2000 Development of Impact Mitigation Strategies Related to the Use of Agent Orange Herbicide in the Aluoi Valley, Vietnam. *Volume 1: Report, Volume 2: Appendices.*
10. Hoang Van Huay, Nguyễn Xuân Cự, 1983. Impacts of toxic chemicals into some chemical features of soil. *Proceeding on International conference on Herbicides used in the war and longterm effects into nature and human*". Hanoi, 1983: 164-169.
11. Luong Van Thanh và nnk., 2004. Full report of Project: Assessment of effects of toxic chemicals into Tri An reservoir, proposal of improved measures. *Document of the program 33, Institute of Water resources science in Souther Vietnam.*
12. Mai Dinh Yen, Nguyen Xuan Quynh, 1983. Aquatic communities in Aluoi districts after 10 years from spraying toxic chemicals. *Proceeding on International conference on Herbicides used in the war and longterm effects into nature and human*". Hanoi, 1983: 272-276.
13. Mai Dinh Yen, Ho Thanh Hai, 2002. The succession of aquatic community in Aluoi area (Thua Thien-Hue) during recent 20 years and the relation to agent orange/dioxin. *Report in Vietnam-Unired States Scientific Conference on Human Helth and Envirenmental effects of Agent Orange/Dioxin. Hanoi , 2002.*
14. Nguyen Xuan Quynh et al., 2005. Short Report of the project: Assessment of effects of toxic chemicals on biodiversity in ecosystems in Mada (Dongnai, Binhphuoc, Binhduong) and Biebhung lake (Bienhoa city). *Document of program 33.*
15. Nguyen Van Truong, 2007. *Journal of Tocycology (6)2007: 15-21.*
16. Phung Tuu Boi, Le Van Cham, 2000. Consequence of herbicides on forest vegetation in Vietnam. *Proceeding of the committee 10/80, Vol. 2, Part 1: Effects of toxic chemicals used in the Vietnam war.*
17. Phung Tuu Boi, 2002. Effects of herbicides sprayed by US army on botanic ecology. *Report in Vietnam-Unired States Scientific Conference on Human Helth and Envirenmental effects of Agent Orange/Dioxin. Hanoi , 2002.*
18. Vo Quy, 1983. Effects of herbicides sprayed by US army on animals in southern Vietnam. *Proceeding on International conference on Herbicides used in the war and longterm effects into nature and human*". Hanoi, 1983:131-133.